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A quantitative analysis of grid-related systematic errors in oxidising capacity and ozone production rates in chemistry transport models

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Abstract. Limited resolution in chemistry transport models (CTMs) is necessarily associated with systematic errors in the calculated chemistry, due to the artificial mixing of species on the scale of the model grid (grid-averaging). Here, the errors in calculated hydroxyl radical (OH) concentrations and ozone production rates 3 are investigated quantitatively using both direct observations and model results. Photochemical steady-state models of radical chemistry are exploited in each case to examine the effect on both OH and 3 of averaging relatively long-lived precursor species, such as O_3, NO_x, CO, H_2O, etc. over different spatial scales. Changes in modelled 3 are estimated, independently of other model errors, by calculating the systematic effect of spatial averaging on the ozone production efficiency 1, defined as the ratio of ozone molecules produced per NO_x molecule destroyed. Firstly, an investigation of in-flight measurements suggests that, at least in the northern midlatitude upper-troposphere/lower stratosphere, averaging precursor species on the scale of a T42 grid (2.75° x 2.75°) leads to a 15-20% increase in OH concentrations and a 5-10% increase in 1. Secondly, results from CTM model experiments are compared at different horizontal resolutions. Low resolution experiments are found to have significantly higher [OH] and 3 compared with high resolution experiments. The extent to which these differences may be explained by the systematic error in the model chemistry associated with grid size is estimated by degrading the high resolution data onto a low resolution grid and then recalculating 1 and [OH]. The change in calculated 1 is found to be significant and can account for much of the difference in 3 between the high and low resolution experiments. The calculated change in [OH] is less than the difference in [OH] found between the experiments, although the shortfall is likely to be due to the indirect effect of the change in modelled NO_x, which is not accounted for in the calculation. It is argued that systematic errors caused by limited resolution need to be considered when evaluating the relative impacts of different pollutant sources on tropospheric ozone.

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